Question

A rocket emits mass (fuel) at a rate α with a speed u relative to the rocket.

(a) Show that the thrust exerted on the rocket by its engines is $u\alpha$.

(b) If the rocket has initial mass on the launch pad of m_0 what is the minimum exhaust velocity that will allow it to lift off *immediately?*

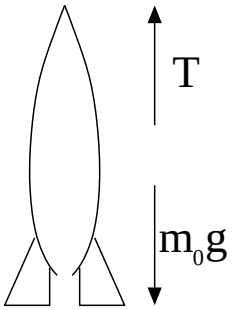
Answer

(a) Thrust is the rate of change of momentum of the rocket.

$$T = m\frac{dv}{dt} = -u\frac{dm}{dt} \text{ (as } mdv = udm)$$

$$\Rightarrow T = u\alpha \text{ as } \frac{dm}{dt} = -\alpha$$

(b)



For immediate start the acceleration of the rocket must be ≥ 0
Therefore $T - m_0 g \geq 0$
$\Rightarrow u \geq \frac{m_0 g}{\alpha}$